WHAT IS CLAIMED:

1. A method for multi-part setup planning for operations to be performed by a bending workstation on a plurality of sheet metal parts in accordance with a composite setup plan, said method comprising:

identifying setup constraints for operations to be performed on each of said plurality of parts;

determining, in accordance with the setup constraints that are identified, operations to be performed on said parts that have compatible setup constraints; and

assigning operations that are determined to have compatible constraints to corresponding tooling stages of the bending workstation to develop a composite setup plan for said plurality of parts;

wherein each of the setup constraints comprises a set of setup constraint parameters, said setup constraint parameters defining setup constraints relating to the positioning of the parts in the workstation to perform said operations.

2. A method for multi-part setup planning according to claim 1, wherein said determining includes identifying a set of said operations that have compatible setup constraints by locating tooling stages that can accommodate each operation within said set of operations.

3. A method for multi-part setup planning according to claim 1, wherein said setup constraint parameters for each part include tooling parameters, at least one of said tooling parameters being defined according to a minimum tooling stage length for each operation that is given by:

L - tolerance,

where "L" is a length of a bend line of the part, and "tolerance" is a predetermined tolerance amount.

4. A method for multi-part setup planning according to claim 1, wherein said setup constraint parameters for each part include tooling parameters, at least one of said tooling parameters being defined according to a maximum allowed tooling stage length for each operation that is given by:

$$Gr + Gl + L - \text{clearance},$$

where "Gr" is a gap length on a right side of a bend position of the part, "Gl" is a gap length on a left side of the bend position of the part, "L" is a length of a bend line at the bend position the part, and "clearance" is a predetermined clearance amount.

5. A method for multi-part setup planning according to claim 1, wherein said setup constraints are identified in accordance with the following:

$(Gr + Gl + L - \text{clearance}) \geq S \geq (L - \text{tolerance})$,

$Gl - .5(\text{clearance}) \geq P$,

$Gr - .5(\text{clearance}) \geq (S - P - L)$,

$Sr \leq (S - P - L + Dr)$, and

$Sl \leq (P + Dl)$,

where "Dl" is a distance between a present tooling stage and a left adjacent tooling stage, "Dr" is a distance between the present tooling stage and a right adjacent tooling stage, "L" is the length of a bend line at the bend position of the part, "S" is a length of the present tooling stage, and "P" is a relative position of the bend line with respect to a left edge of the present tooling stage.

6. A method for multi-part setup planning according to claim 1, wherein said identifying includes determining each of the setup constraints based on an intermediate shape of the part and a configuration of the tooling of the bending workstation for each operation.

7. A method for multi-part setup planning according to claim 6, wherein said determining includes providing a geometric model of the intermediate shape of the part and the configuration of the tooling, and calculating part-tool intersection regions to determine setup constraint parameters for each operation.

8. A multi-part setup planning system for generating a composite setup plan for operations to be performed by a bending workstation on a plurality of sheet metal parts, said system comprising:

a constraint identifier that identifies setup constraints for operations to be performed on each of said plurality of parts;

a judgement apparatus that determines, in accordance with the setup constraints that are identified by said identifier, operations to be performed on said parts that have compatible setup constraints; and

an operations assignor that assigns operations that are determined to have compatible constraints to corresponding tooling stages of the bending workstation to thereby develop a composite setup plan for said plurality of parts;

wherein each of the setup constraints comprise a set of setup constraint parameters, said setup constraint parameters defining setup constraints relating to the positioning of the parts in the workstation to perform said operations.

9. A multi-part setup planning system according to claim 8, wherein said judgement apparatus comprises an operations identifier that identifies a set of said operations that have compatible setup constraints by locating tooling stages that can accommodate each operation within said set of operations.

10. A multi-part setup planning system according to claim 8, wherein said setup constraint parameters for each part include tooling parameters, at least one of

said tooling parameters being defined according to a minimum tooling stage length for each operation that is given by:

L - tolerance,

where "L" is a length of a bend line of the part, and "tolerance" is a predetermined tolerance amount.

11. A multi-part setup planning system according to claim 8, wherein said setup constraint parameters for each part include tooling parameters, at least one of said tooling parameters being defined according to a maximum allowed tooling stage length for each operation that is given by:

Gr + Gl + L - clearance,

where "Gr" is a gap length on a right side of a bend position of the part, "Gl" is a gap length on a left side of the bend position of the part, "L" is a length of a bend line at the bend position the part, and "clearance" is a predetermined clearance amount.

12. A multi-part setup planning system according to claim 8, wherein said setup constraints are identified by said constraint identifier in accordance with the following:

(Gr+Gl+L-clearance) ≥ S ≥ (L-tolerance),

Gl-.5(clearance)≥P,

Gr - .5(clearance) ≥ (S-P-L),

Sr≤ (S-P-L+Dr), and

Sl≤ (P+Dl),

where "Dl" is a distance between a present tooling stage and a left adjacent tooling stage, "Dr" is a distance between the present tooling stage and a right tooling stage, "L" is the length of a bend line at the bend position of the part, "S" is a length of the present tooling stage, and "P" is a relative position of the bend line with respect to a left edge of the present tooling stage.

13. A multi-part setup planning system according to claim 8, wherein said constraint identifier comprises a determination apparatus that determines each of the setup constraints based on an intermediate shape of the part and a configuration of the tooling of the bending workstation for each operation.

14. A multi-part setup planning system according to claim 13, wherein said determination apparatus that determining each of the setup constraints comprises a distributor that provides a geometric model of the intermediate shape of the part and the configuration of the tooling, and a calculator that calculates part-tool intersection regions to determine setup constraint parameters for each operation.

15. A multi-part setup planning system according to claim 8, further comprising a determination apparatus that determines a tooling stage arrangement for said bending workstation, said stage arrangement judgement apparatus comprising an identification apparatus that identifies required tooling stages of the composite setup plan and a generator that generates an arrangement of the required tooling stages in the bending workstation to minimize a transfer frequency of said parts between the tooling stages.

16. A method for setup planning for operations to be performed by a workstation in accordance with a shared setup plan, said method comprising:

defining a family of parts;

identifying setup constraints imposed by operations to be performed on each part of said family of parts; and

generating a shared setup plan that satisfies all of the setup constraints that are identified for said family of parts;

wherein each of the setup constraints comprises a set of setup constraint parameters, said setup constraint parameters defining setup constraints relating to the positioning of each part in the workstation to perform said operations.

17. A method for setup planning according to claim 16, wherein said generating comprises:

determining, in accordance with the setup constraints that are identified, operations to be performed on said parts that have compatible setup constraints; and

assigning operations that are determined to have compatible constraints to corresponding tooling stages of the workstation to develop the shared setup plan for said family of parts.

18. A method for setup planning according to claim 17, wherein said determining includes identifying a set of said operations that have compatible setup constraints by locating tooling stages that can accommodate each operation within said set of operations.

19. A method for setup planning according to claim 16, wherein said setup constraint parameters for each part include tooling parameters, at least one of said tooling parameters being defined according to a minimum tooling stage length for each operation that is given by:

$$L - \text{tolerance},$$

where "L" is a length of a bend line of the part, and "tolerance" is a predetermined tolerance amount.

20. A method for setup planning according to claim 16, wherein said setup constraint parameters for each part include tooling parameters, at least one of said tooling parameters being defined according to a maximum allowed tooling stage length for each operation that is given by:

$$Gr + Gl + L - \text{clearance},$$

where "Gr" is a gap length on a right side of a bend position of the part, "Gl" is a gap length on a left side of the bend position of the part, "L" is a length of a bend line at the bend position the part, and "clearance" is a predetermined clearance amount.

21. A method for setup planning according to claim 16, wherein said setup constraint parameters for each part comprise: a gap length "Gr" on a right side of a bend position of the part, which denotes the distance by which a tooling stage can be extended towards the right side of the bend position; a gap length "Gl" on a left side of the bend position of the part, which denotes the distance by which a tooling stage can be extended towards the left side of the bend; an obstruction length "Or" on the right side of the bend position; which denotes a space in which not tooling is allowed on the right side of the bend position; an obstruction length "Ol" on the left side of the bend position; which denotes a space in which no tooling is allowed on the left side of the bend position; a safety distance "Sr" on the right side of the bend position, which denotes a minimum distance between the bend position and a next tooling stage towards the right side of the bend position; and a safety distance "Sl" on the left side of the bend position, which denotes a minimum distance between the bend position and a next tooling stage towards the left side of the bend position.

22. A method for setup planning according to claim 21, wherein said setup constraints are identified in accordance with the following:

$(Gr + Gl + L - clearance) \geq S \geq (L - tolerance)$,

$Gl - .5(clearance) \geq P$,

$Gr - .5(clearance) \geq (S - P - L)$,

$Sr \leq (S - P - L + Dr)$, and

$Sl \leq (P + Dl)$,

where "Dl" is a distance between a present tooling stage and a left adjacent tooling stage, "Dr" is a distance between the present tooling stage and a right adjacent tooling stage, "L" is the length of a bend line at the bend position of the part, "S" is a length of the present tooling stage, and "P" is a relative position of the bend line with respect to a left edge of the present tooling stage.

23. A method for setup planning according to claim 16, wherein said identifying includes determining each of the setup constraints based on an intermediate shape of the part and a configuration of the tooling of the workstation for each operation.

24. A method for setup planning according to claim 23, wherein said determining includes providing a geometric model of the intermediate shape of the part and the configuration of the tooling, and calculating part-tool intersection regions to determine setup constraint parameters for each operation.

25. A setup planning system for generating a shared setup plan for operations to be performed by a workstation, said system comprising:

a definition apparatus that defines a family of parts;

an identification apparatus that identifies setup constraints imposed by operations to be performed on each part of said family of parts; and

a generator that generates a shared setup plan that satisfies all of the setup constraints that are identified for said family of parts;

wherein each of the setup constraints comprises a set of setup constraint parameters, said setup constraint parameters defining setup constraints relating to the positioning of each part in the workstation to perform said operations.

26. A setup planning system according to claim 25, wherein said generator comprises:

a judgement apparatus that determines, in accordance with the setup constraints that are identified, operations to be performed on said parts that have compatible setup constraints; and

a control apparatus that assigns operations that are determined to have compatible constraints to corresponding tooling stages of the workstation to develop the shared setup plan for said family of parts.

27. A setup planning system according to claim 26, wherein said judgement apparatus includes an identifier that identifies a set of said operations that have compatible setup constraints by locating tooling stages that can accommodate each operation within said set of operations.

28. A setup planning system according to claim 25, wherein said setup constraint parameters for each part comprise: a gap length "Gr" on a right side of a bend position of the part, which denotes the distance by which a tooling stage can be extended towards the right side of the bend position; a gap length "Gl" on a left side of the bend position of the part, which denotes the distance by which a tooling stage can be extended towards the left side of the bend; a obstruction length "Or" on the right side of the bend position, which denotes a space in which not tooling is allowed on the right side of the end position; an obstruction length "Ol" on the left side of the bend position; which denotes a space in which not tooling is allowed on the left side of the bend position; a safety distance "Sr" on the right side of the bend position, which denotes a minimum distance between the bend position and a next tooling stage towards the right side of the bend position; and a safety distance "Sl" on the left side of the bend position, which denotes a minimum distance between the bend position and a next tooling stage towards the left side of the bend position.

29. A setup planning system according to claim 28, wherein said setup constraints are identified by said identifier in accordance with the following:

$(Gr + Gl + L - clearance) \geq S \geq (L - tolerance)$,

$Gl - .5(clearance) \geq P$,

$Gr - .5(clearance) \geq (S - P - L)$,

$Sr \leq (S - P - L + Dr)$, and

$Sl \leq (P + Dl)$,

where "Dl" is a distance between a present tooling stage and a left adjacent tooling stage, "Dr" is a distance between the present tooling stage and a right adjacent tooling stage, "L" is the length of a bend line at the bend position of the part, "S" is a length of the present tooling stage, and "P" is a relative position of the bend line with respect to a left edge of the present tooling stage.

30. A setup planning system according to claim 25, wherein said setup constraint parameters for each part include tooling parameters, at least one of said tooling parameters being defined according to a minimum tooling stage length for each operation that is given by:

L - tolerance,

where "L" is a length of a bend line of the part, and "tolerance" is a predetermined tolerance amount.

31. A setup planning system according to claim 25, wherein said setup constraint parameters for each part include tooling parameters, at least one of said tooling parameters being defined according to a maximum allowed tooling stage length for each operation that is given by:

Gr + Gl + L - clearance,

where "Gr" is a gap length on a right side of a bend position of the part, "Gl" is a gap length on a left side of the bend position of the part, "L" is a length of a bend line at the bend position the part, and "clearance" is a predetermined clearance amount.

32. A setup planning system according to claim 25, wherein said identification apparatus includes a judgement apparatus that determines each of the setup constraints based on an intermediate shape of the part and a configuration of the tooling of the workstation for each operation.

33. A setup planning system according to claim 32, wherein said judgement apparatus includes a distributor that provides a geometric model of the intermediate

shape of the part and the configuration of the tooling, and a calculator that calculates part-tool intersection regions to determine setup constraint parameters for each operation.